



Microstrip Sierpinski Carpet Antenna Design

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Abstract -- Low cost of fabrication and low profile features of microstrip antennas, attract many researchers to investigate the performance of this antenna in various ways. Today, fractal antenna becomes popular among the researcher because they have a peculiar properties that make them suitable for multiband applications. Fractal technologies allowed us to design miniature antennas and integrate multiple telecommunication services such as cellular (GSM 900 and GSM 1800), wireless LAN, GPS and HiperLAN into a single device. Microstrip Sierpinski carpet antenna is proposed for a multiband operation. The fractal antenna offer solutions for the integration of all this application.

1. Introduction

The recent explosion in the mobile communication market has forced stricter requirement for mobile terminal antennas. The terminals for 3G must be compatible with 2G system. The growing of wireless local area network WLAN and Bluetooth system has already demanded specific attention. Therefore a new terminal antenna should support a multisystem operation. Using this multi system in one antenna it will reduce the complication of the system

Printed circuit antenna or microstrip antenna are desired in many instances due to space constrains in the modern electronic devices. In conventional microstrip patch antennas, dual band or multi-frequency operation can be obtained by employing multiple radiating elements or tuning devices such as varactor diode[1,2]. This method make antennas more

complicated. In this project, the concept of a fractal has been applied to the geometry of a square microstrip patch antenna to obtain multiband frequency operation.

Fractals are objects, which displays self similarity on all scales. A fractal object exhibits exactly the same structure at all scales or the same type of structure appears on all scales. Fractal technology allowed us to design miniature antennas and integrate multiple telecommunication services into a single device. Fractals are objects, which display self-similarity on all scales [3]. Two basic characteristics of a fractal are self-similarity and the fractal dimension. An object is said to be self-similar if it look roughly the same on any scale. The estimated length L , of an object equals the length of the ruler multiplied by a number N .

Fractal antennas are antennas that have the shaped of fractal structures. The fractal antennas consist of geometrical shapes that are repeated. Each one of the shapes has unique attributes. There are many fractal geometries such as Sierpinski gasket, Sierpinski carpet, Koch island, Hilbert curve and Miskowski. In this paper microstrip Sierpinski carpet antenna has been designed and analyzed.

The Sierpenksi carpet is constructed using squares geometries. In order to start this type of fractal antenna it begins with a square in the plane and divided into nine smaller congruent squares where the open central square is dropped. The remaining eight squares are divided into another nine smaller congruent squares with each central are dropped. Figure 1 shows the process of iteration for Sierpenski carpet fractal antenna. The iteration for this process is up to third iteration.

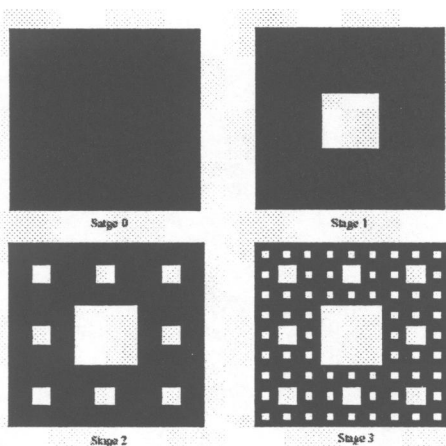


Figure 1 Sierpinski carpet square antenna with third iteration

2. Antenna Configuration

In this paper, a microstrip sierpinski carpet antenna using transmission line feeding was presented. This antenna was design up to second iteration. The radiating elements were printed on a copper clad material FR-4. The design of the antenna starts with the single element of the basic square patch operating at 1.8 GHz. The simulation for the basic square structure with transmission line feeding resulted in antenna size of 38 mm x 38 mm. Figure 2 shows the design step for a sierpinski carpet fractal antenna starting with a square geometry of a single patch antenna. Figure 3 shows the sierpinski carpet antenna with transmission line feed.

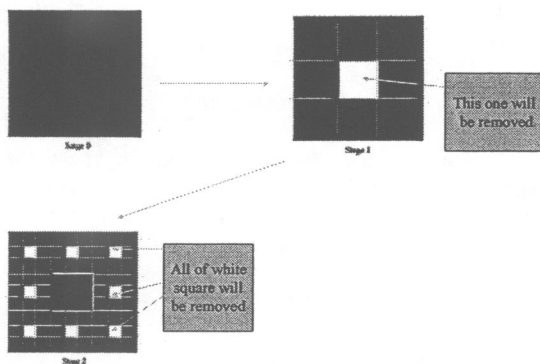


Figure 2: A step to design a sierpinski carpet.

The Sierpinski carpet is constructed using squares geometry of microstrip antenna. For the fractal design this procedure has to be followed [3]

Let N_n be the number of black boxes,
 L_n the ratio for the length,
 A_n the ratio for the fractional area after the n th iteration and
 d_n is the capacity dimension. Then

$$N_n = 8^n \quad (1)$$

$$L_n = \left(\frac{1}{3}\right)^n \quad (2)$$

$$A_n = \left(\frac{8}{9}\right)^n \quad (3)$$

$$d_n = -\lim_{n \rightarrow \infty} \left(\frac{\ln N_n}{\ln L_n} \right) = 1.89 \quad (4)$$

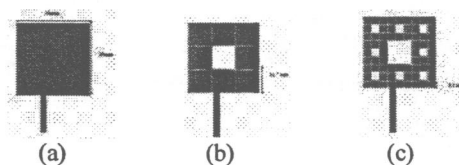


Figure 3 Microstrip sierpinski carpet antenna with transmission line feeding of (a) zero iteration, (b) first iteration, (c) second iteration.

3. Simulation and Measurement Results

Return loss measurement was carried out using agilent network analyzer. The measurement and simulation plot of return loss is shown in Figure 4. Figure 5 shows the fabricated antenna using FR4 material substrate with $\epsilon_r = 4.5$ and thickness = 1.6 mm. The loss tangent of this material is 0.019

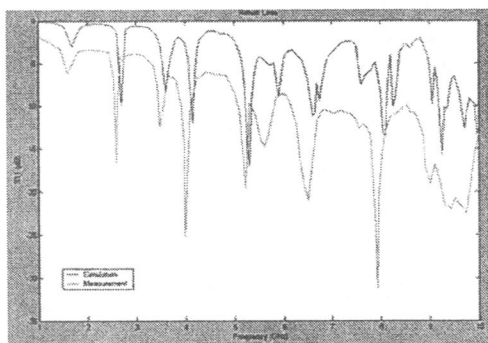


Figure 4 Measurement and simulation result of return loss for microstrip sierpinski carpet fractal antenna

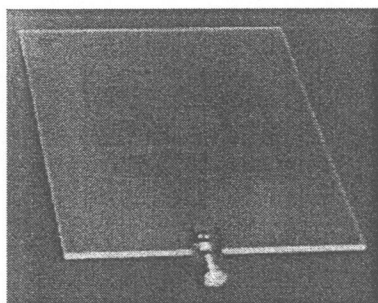


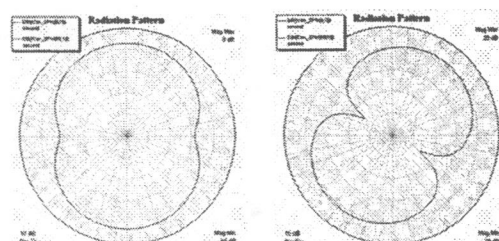
Figure 5 Fabricated sierpinski carpet antenna antenna

Table 1 Measurement results for microstrip sierpinski carpet antenna

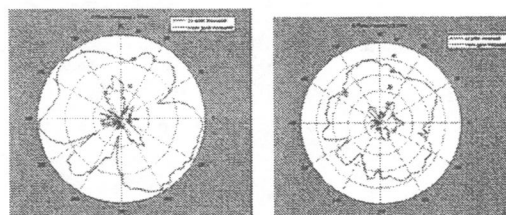
Band	1	2	3	4	5
Frequency (GHz)	2.59	3.48	3.99	5.2	7.93
Return Loss (dB)	-16.65	-12.9	-25.24	-19.73	-31.17
BW(%)	1.6	1.8	5	12.96	47.1

The pattern of return loss as shown in figure 4 is quite similar for simulation and measurement but the measurement result is better than simulation results in term of return loss value. The best value of return loss is at -31.17dB occurred at 7.93GHz and -25.24dB at 3.99GHz.

For the first band the bandwidth is only 1.6%, its increase to 1.8% for the second band. The widest bandwidth is 47.1% at the fifth band.



(a) 2.59 and 5.2 GHz



(b) 2.59 and 5.2 GHz

Figure 6: Radiation patterns of misrostrip sierpinski carpet antenna.

- (a) Simulation
- (b) Measurement

The far-field radiation pattern has been measured in an anechoic chamber at Wireless Communication Center (WCC), UTM. The typical measured co-polar and cross-polar radiation pattern at the first and four bands are illustrated in Figure 6. The radiation pattern for both frequencies is more toward omnidirectional. The cross polar isolation is very minimum at the two bands of frequency.

4. Conclusion

A square microstrip sierpinski carpet antenna was constructed using fractal geometry for multiband operation. The measured results indicate that the antenna exhibits a good input return loss at the designed frequency and other multiband frequency. From measurement and simulation the multiband frequency occur at 6 difference resonance frequency with a return loss more than 10 dB. The radiation pattern shows this antenna can perform similar with a dipole antenna. This type of antenna is the best candidate for future broadband wireless communications.

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